The Number of *Draeculacephala* Species in Hawaii (Homoptera: Cicadellidae)[1]

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The genus *Draeculacephala* Ball, 1901, was considered a synonym of *Acopsis* Amyot & Serville, 1834, by Evans (1947). Zimmerman (1948) and Young (1949) followed Evans in the use of *Acopsis*. However, Oman (1949) after examining the type specimens of the genotype *Acopsis viridicans* Amyot & Serville, from Madacasgar affirmed that *Draeculacephala* is a distinct genus from *Acopsis*. The distribution of the genus *Draeculacephala* extends from Arctic North America to Cuba, Mexico and Hawaii. There are at least 21 species of *Draeculacephala* in the Nearctic region (Young & Davidson, 1959).

The species in the genus *Draeculacephala* have been of interest to entomologists because they have been of either potential or real economic importance. In the temperate areas certain species of this genus are known to attack cereal and forage crops (Gibson, 1915). In California, *D. minerva* Ball has been reported to be a vector of Pierce's disease of grapes (Frazier, 1944; Jensen, 1946; Freitag *et al.*, 1952). Another species, *D. mollipes* (Say), has been reported to attack sugarcane in continental United States (Muir, 1913). In Cuba *D. portola* Ball is known to attack rice (Young & Davidson, 1959). In Hawaii, *D. mollipes* was reported to be a serious pest of water cress (Holdaway, 1946). Recently large numbers of *Draeculacephala*, presumably *D. minerva*, were observed on rice and other grasses at Wailua, Kauai. The same species was also observed at Pearl City, Oahu.

During the course of recent studies on the biology and ecology of *Draeculacephala* attacking rice, it became evident that there was confusion in the past as to how many species existed in Hawaii. The first report of the occurrence of *Draeculacephala* in Hawaii was that of Muir (1913). The specimens were collected by J. Nunes in Honolulu in 1912, and identified by Van Duzee as *D. mollipes* (Zimmerman, 1948). They were later identified by Oman in 1942 as *D. minerva* (Swezey, 1943). The occurrence of *D. mollipes* was reported from Oahu in 1934, Hawaii in 1936 and Kauai in 1939 (Zimmerman, 1948). In 1959, Young & Davidson reported the occurrence of *D. portola* in Hawaii.

Examination of specimens collected in the past and present has led us to doubt the presence of *D. mollipes* and *D. portola* in Hawaii. The

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present paper presents evidences to show that only one species, *D. minerva*, is present in Hawaii.

Materials and Methods

Specimens of *Draeculacephala* were collected from different locations in Hawaii. The pertinent diagnostic characters used by earlier workers to differentiate *D. minerva*, *D. mollipes* and *D. portola* were used. Male and female genitalia were dissected and examinations made on temporary glycerine mounts. The genitalia were prepared by taking abdomens of the specimens and boiling them in 10% KOH solution for few seconds. It was then washed in acidified water and mounted in glycerine. All measurements were made by the use of an ocular micrometer with 0.01 mm divisions.

The specimens examined were from various sources; University of Hawaii, State Department of Agriculture, and field collections made by the authors on Oahu, Kauai and Hawaii. The specimens of *Draeculacephala* investigated were from the following locations:

Oahu:

Kaaawa, 50 ♂♂, 50 ♀♀, 11.III.1971, on para grass (*Panicum purpurascens* Raddi), B. Napompeth.

Waimanalo, 50 ♂♂, 50 ♀♀, 18.III.1971, on para grass (*Panicum purpurascens* Raddi), B. Napompeth.

Pearl City, 20 ♂♂, 20 ♀♀, 15.VII.1970, on rice (*Oryza sativa* L.) and jungle rice (*Echinochloa colonum* (L.) Link), V. Rungvatana.

Kauai:

Kapaa, 15 ♂♂, 16 ♀♀, IV.1969, on rice (*Oryza sativa* L.), I. Buddenhagen.

Wailua, 7 ♂♂, 16 ♀♀, 3.IV.1971, on para grass (*Panicum purpurascens* Raddi), T. Nishida.

Hawaii:

Kamuela, 7 ♂♂, 4 ♀♀, IX.1970, on bur clover (*Medicago* sp.), T. Nishida.

The specimens from water cress (*Nasturtium officinale* R.Br.) were all from Oahu and obtained from the University of Hawaii collection with the following data:

Kuapa Pond, 1 ♂, 2 ♀♀, 19.V.1943, Y. Tanada.

Waialua, 7 ♂♂, 9 ♀♀, 14.III.1945, D.D. Jensen.

Waimea, 1 ♂, 14.III.1945, D.D. Jensen.

The specimens collected from Kaaawa, Waimanalo, Pearl City, Kapaa and Wailua where *Draeculacephala* occurred in great numbers were used for taking morphological measurements. Data on measurements from specimens collected from water cress were pooled. The genitalia dissected were preserved for future reference.

Identified specimens of *D. mollipes* and *D. portola* of both sexes were obtained from Lexington, Kentucky and Scioto County, Ohio. The genitalia were dissected and preserved for future comparison and reference.

Evaluation of Taxonomic Characters

According to literature three species of *Draeculacephala* have been reported from Hawaii. These are *D. minerva*, *D. mollipes* and *D. portola*. When Zimmerman's key (Zimmerman, 1948) was used all specimens keyed out to *D. mollipes*. When Young & Davidson's key (Young & Davidson, 1959) was used all specimens, including those earlier identified as *D. mollipes*, keyed out to *D. minerva*. None of them led to *D. portola*. This situation stemmed from the differences in the taxonomic characters utilized. The main diagnostic characters used were as follows: (1), Body length; (2), Vertex to pronotum ratios of females; (3), Inner apical cell to claval commissure ratios of males; (4), Shape of the last ventral segment of males; (5), Length of female second valvula; and (6), Structure of aedeagus.

BODY LENGTH

The body lengths of *D. minerva*, *D. mollipes* and *D. portola* were highly variable (Table 1, Fig. 1). In both sexes the body length of *D. minerva* was the shortest; *D. mollipes*, intermediate; and *D. portola*, longest. The size range was least in *D. mollipes*, intermediate in *D. minerva*, and greatest in *D. portola*. Overlapping in the body lengths was evident in both sexes, but appeared to be more pronounced among females.

The mean body length of all males in the Hawaiian collections fell within the shorter end of the size range of *D. minerva*. They did not fall within the size range of the males of either *D. mollipes* or *D. portola*. Among the females, however, there was considerable overlapping in the size ranges of the three species (Fig. 1).

Thus if the body length criterion were used all Hawaiian male *Draeculacephala* could be *D. minerva*. However, the females could be either *D. minerva* or *D. mollipes*. They could also be small individuals of *D. portola*.

VERTEX TO PRONOTUM RATIO OF FEMALES

In the original descriptions of *D. minerva* and *D. portola*, Ball (1927) used the ratio of the median length of the vertex to that of the pronotum of females as a diagnostic character. The lengths of vertex and pronotum were equal in *D. minerva*, and the vertex was one-third longer than the pronotum in *D. portola*. Zimmerman (1948) also used the relative lengths of these structures in differentiating *D. minerva* from *D. mollipes* in Hawaii, vertex and pronotum being equal in the former and the vertex being distinctly longer in the latter.

TABLE 1. *Diagnostic characters for differentiating* D. minerva, D. mollipes, *and* D. portola.

Characters	*D. minerva*	*D. mollipes*	*D. portola*	*Reference*
1. Body length (mm)	6.0 (♂) 7.0 (♀) 5.2–6.5 (♂) 6.0–7.8 (♀)	— — 6.2–6.7 (♂) 7.5–7.8 (♀)	8.5 (♂) 11.0 (♀) 6.5– 7.9 (♂) 7.0–10.8 (♀)	Ball, 1927 Young & Davidson, 1959
2. Vertex to pronotum ratio (♀)	Equal Subequal	— Distinctly longer	1/3 longer —	Ball, 1927 Zimmerman, 1948
3. Inner apical cell to claval commissure ratio (♂)	6:10	—	More than 6:10	Young & Davidson, 1959
4. Last ventral segment (♂)	—	—	Long, narrow, & tubular	Ball, 1927
5. Length of second valvula (mm)	2.3	—	2.3	Young & Davidson, 1959
6. Aedeagus	Dorsal protruberance triangular; shaft oval in caudoventral aspect.	Dorsal protruberance smoothly convexed; shaft narrowly oval in caudoventral aspect.	Dorsal protruberance triangular; shaft pyriform in caudoventral aspect.	Young & Davidson, 1959.

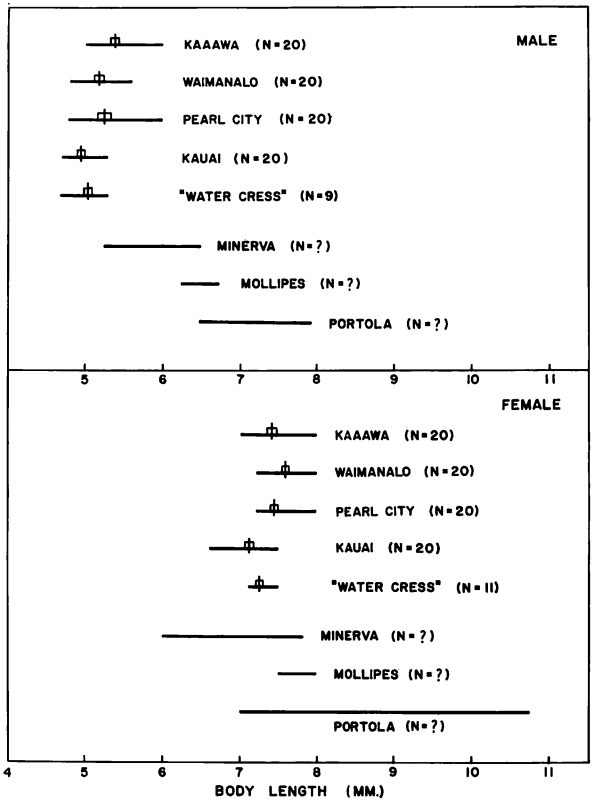

FIG. 1. The parameter of body lengths of Hawaiian *Draeculacephala* and those of *D. minerva*, *D. mollipes* and *D. portola*. The horizontal lines indicate ranges in body length; vertical lines, the means; and the rectangles, standard deviations.

Measurements of the vertex and pronotum of Hawaiian specimens revealed that the average length of the vertex was slightly longer than that of the pronotum in all cases. The ratios were 1.31: 1.11 (1.18), 1.41: 1.17 (1.20), 1.31: 1.08 (1.21), 1.37: 1.11 (1.23) and 1.31: 1.12 (1.17) for specimens from Kaaawa, Waimanalo, Pearl City, "water cress" and Kauai respectively. All specimens, including those on water cress, had ratios greater than unity which means that the vertex was longer than the pronotum, and that all ratio values were less than 1.3 or one-third longer. It was this taxonomic character that Zimmerman (1948) used to identify the *Draeculacephala* collected on water cress as *D. mollipes*. Thus Zimmerman's key would lead to the identification of *Draeculacephala* on water cress as well as all others in Hawaii as *D. mollipes*.

INNER APICAL CELL TO CLAVAL COMMISSURE RATIOS OF MALES

The ratio of the length of the inner apical cell to the length of the

claval commissure was used by Young & Davidson (1959) as a taxonomic character. This ratio was 6: 10 (0.60) in *D. minerva* and greater than this value in *D. mollipes.*

The ratios obtained from the Hawaiian specimens were 1.72: 2.30 (0.75), 1.63: 2.30 (0.71), 1.64: 2.30 (0.71), 1.62: 2.30 (0.70) and 1.57: 2.18 (0.72) from specimens taken from Kaaawa, Waimanalo, Pearl City, "water cress" and Kauai respectively. In all samples the ratios exceeded 6: 10 (0.60), a value considered to be characteristic to *D. mollipes.*

It was further noted that the ratio of the lengths of the inner apical cell to claval commissure was a poor character because the structure of the inner apical cells was variable. The number of cells in the inner apical cell varied, some of them were two-celled, or even more.

SHAPE OF THE LAST VENTRAL SEGMENT OF MALES

The shape of the last ventral segment of males has been used as a taxonomic character for differentiation of *D. portola* (Ball, 1927). It is long, narrow and tubular in *D. portola,* but not so in *D. minerva* (Ball, 1927).

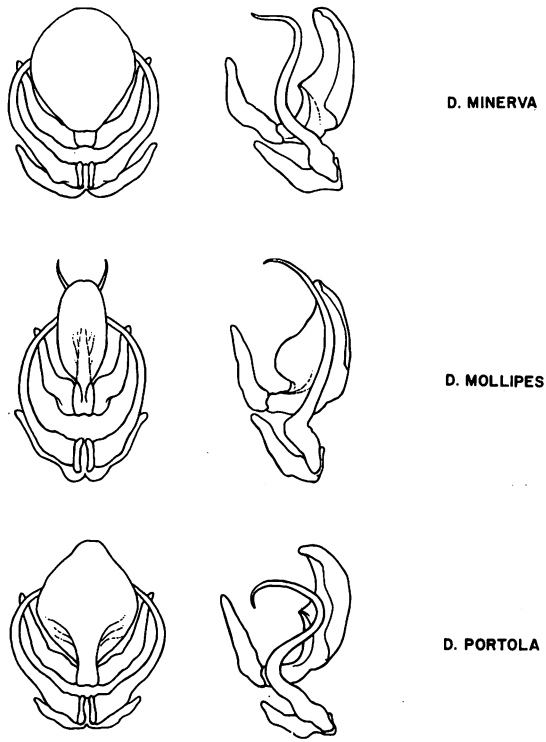

FIG. 2. The structure of the male genitalia of *D. minerva, D. mollipes* and *D. portola.*

Because the aedeagi of *D. minerva* and *D. portola* are very similar (Young & Davidson, 1959), the last ventral segment is the decisive character in differentiating the two species.

An examination of the last ventral segment of all the male *Draeculacephala* sampled in Hawaii indicated that *D. portola* is not present in Hawaii.

LENGTH OF FEMALE SECOND VALVULA

The length of the female second valvula was used by Young & Davidson (1959) as a diagnostic character separating *D. minerva* from *D. portola.* The length was less than 2.3 mm in *D. minerva* and longer in *D. portola.* No second valvulae examined in this study exceed 2.3 mm in length.

The second valvula is apparently a poor diagnostic character, for Bierne (1956) pointed out earlier that the females of *Draeculacephala* were difficult to identify reliably in the absence of males, and that the internal male genitalia must be examined for reliable identification.

STRUCTURE OF AEDEAGUS

The structure of the aedeagus was used as a taxonomic character by Young & Davidson (1959). The structure of the aedeagi of *D. minerva* from Hawaii, *D. mollipes* from Ohio and *D. portola* from Kentucky are shown in Fig. 2. Without exception the structure of the aedeagus of all specimens examined from Hawaii was identical to that of *D. minerva.* It is, therefore, definite that *D. minerva* is the only species of *Draeculacephala* present in Hawaii.

CONCLUSIONS

Three species of *Draeculacephala* have been reported from Hawaii, viz, *D. minerva*, *D. mollipes* (Zimmerman, 1948) and *D. portola* (Young & Davidson, 1959). An examination of various morphological characters used in the indentification of these species indicated that *D. minerva* is the only species present in Hawaii.

The earlier records of the occurrence of *D. mollipes* in Hawaii need clarification. The record of *D. mollipes* in Hawaii by Muir (1913) was not controversial at that time because *D. minerva* was not described by Ball until 1927 from specimens collected in California. However, such records from 1927 to date, including those reported a pest of water cress, were due to misidentification.

The record of *D. portola* being introduced and becoming established in Hawaii by Young & Davidson (1959) is questionable. Young (1971) believed that the statement was based on the examination of specimens deposited at the United States National Museum. The present investigation yielded no evidence on the presence of *D. portola* in Hawaii.

The list of parasites of *Draeculacephala* in Hawaii was given by Zimmer-

man (1948). There were four egg parasites of *D. minerva* reported, viz, *Lymaenon* (=*Gonatocerus*) *mexicanus* Perkins, *Oligosita caerulocephala* (Fullaway), *Paracentrobia* (=*Brachystella*) *lutea* (Fullaway) and *Ootetrastichus beatus* Perkins. There are no reports on the parasites for *D. mollipes*, which was reported to occur on water cress. The absence of egg parasites of *D. mollipes*, now known to be *D. minerva*, indicates that the parasites do not attack *Draeculacephala* when it breeds on water cress.

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